特開平11-296820 英訳



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## DETAILED DESCRIPTION

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[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the quantity-relation between the thickness of the permanent magnet film and residual magnetization which constitute especially the playback component section, and regenerative-track width of face about the magneto-resistive effect mold magnetic head (MR head) used for magnetic recording media, such as a hard disk drive unit and VTR.
[0002]
[Description of the Prior Art] In magnetic recording media, such as a hard disk drive unit or VTR, small large capacity-ization by high recording density is progressing with rapid vigor. High performance-ization of the magnetic head is advanced in response to such a trend, and the MR head which used the magneto-resistive effect phenomenon for the playback component came to be applied instead of the thin film magnetic head which is an electromagnetic induction type.
[0003] Such a conventional MR head is indicated by IEEE Tras.Magn.Vol 26(1990) pp1689. The outline is explained using drawing 12 . The magneto-resistive effect mold component (MR component) 91 which reproduces the magnetic signal on a magnetic-recording medium consists of thin films of the ingredient which has magneto-resistive effects, such as a permalloy. This MR component 91 is pinched with the shielding magnetic films 93 and 94 through the playback gap 92 which consists of a non-magnetic material.
[0004] The MR head shown in this drawing 12 is the thing of the type which a recording head and the reproducing head have separated. The reproducing head is the MR component 91 and reads signaling information using the MR component 91 at the time of playback. A recording head is the induction type magnetic head only for records which consists of a record magnetic pole 84 and a coil 80. The record magnetic pole 84 and coil 80 which constitute a recording head are arranged in the upper part of the MR component 91 which constitutes the reproducing head, as shown in drawing 12 .
[0005] in order to make the storage capacity increase in a magnetic recording medium -- usually -- track density -- or raising track recording density is performed. Then, in order to raise track density, the width of recording track must be narrowed. It is made to follow on the width of recording track decreasing, and the following faults arise.

[0006] That is, since the die length of MR component becomes short, resistance of the MR component itself will fall and a playback output will decrease remarkably. For this reason, [0007] which needs to provide the means which increases resistance of a playback component or raises the playback sensibility of MR component in order to maintain a playback output at extent which does not become a problem practically On the other hand, MR component which is a detection playback component tends to be influenced of the magnetic domain wall generated in a component, and magnetic-domain structure, and superimposes it on a regenerative signal as a noise at the time of playback. Such a noise signal was called the Barkhausen noise, the control and regulation were made an issue of, and the cure has been performed. Permanent magnet film which is indicated by IEEE Trans.Magn.Vol.32(1996) pp19 is made to adjoin MR component as a means for controlling generating of a magnetic domain, formation arrangement is carried out, and there is a method of impressing a bias magnetic field to the MR component. According to this approach, it becomes possible to control that an impression bias magnetic field can ease the effect of the demagnetizing field generated at the truck edge of MR component, consequently a magnetic domain etc. generates it in a component.

[0008] However, if stabilization of magnetic-domain structure is attained using the permanent magnet film, a possibility of reducing the playback sensibility of a component will arise. Therefore, cautions are required for selection of the bias magnetic field strength for stabilization.

[0009] That is, impressing required magnetic field strength so that a Barkhausen noise may not occur, and holding the reinforcement of a bias magnetic field and not reducing playback sensibility within proper limits are called for. moreover -- all these elements if the reinforcement of a bias magnetic field is changed, since the asymmetry which is the index of the linearity of a regenerative signal will also be changed -- satisfaction **** -- it is necessary to set up the optimal bias magnetic field

[0010] On the other hand, U.S. Pat. No. 5434826 is indicating the quality of the material and a presentation with this desirable permanent magnet film. Then, the permanent magnet film currently indicated has CoCrPt, CoCrTa, CoCrTaPt, CoCrPtB, etc., and it is shown clearly that the case where the product of residual magnetization and thickness is set to 2.38-3.78 [memu/cm2] is the optimal region to the thickness of the range which is 50-60nm using the measuring device produced uniquely.

[0011] furthermore -- while the magnetic properties of this permanent magnet film are natural -- the reproducing-characteristics size of an MR head -- although it has **** effect, JP,7-93714,A can reduce dispersion in the playback output of a Barkhausen noise or an MR head by raising the property of the coercive force Hc of the permanent magnet film -- thing explanation is given.

[0012]

[Problem(s) to be Solved by the Invention] The bias magnetic field which the permanent magnet film generates is effective in controlling and stabilizing the magnetization rotation in MR component. However, if spacing of the adjoining permanent magnet film becomes narrow across the range considered

conventionally with the formation of truck narrow smallness for raising recording density, the reinforcement of a bias magnetic field will become excessive. Consequently, the sensibility of MR component falls and reduction of a playback output is no longer avoided. Furthermore, since the effectiveness of a bias magnetic field separates from a proper value, quickly, coincidence is anxious about narrowing and the increment for asymmetry in a playback wave, and the linearity range of the regenerative signal which guarantees the symmetric property of a playback wave leads to increase of the error rate of a regenerative signal.
[0013] The purpose of this invention is to offer the practical solution approach for obtaining the MR head which reduces wave-like asymmetry while it removes the playback instability of MR component looked at by generating of a Barkhausen noise and heightens a regenerative-signal output. Moreover, application of the optimal permanent magnet film corresponding to reduction in the width of recording track is offered. Hereafter, this invention will be stated to a detail.
[0014]
[Means for Solving the Problem] In order to solve the technical technical problem mentioned above, this invention adds consideration about a physical dimension or a physical-properties value of the playback output of MR component, the permanent magnet film which has great effect on a playback noise, and regenerative-track width of face etc., and as a result of groping for the concrete technique which can be appropriately reflected in a design, it hits on an idea of it.
[0015] The permanent magnet film used for an MR head performs noise control by impressing a bias magnetic field to a component. However, if a bias magnetic field is too large, it will become the cause which playback sensibility falls and causes lack of an output. Moreover, as for the effectiveness of the bias magnetic field by the permanent magnet film, the effectiveness changes with the residual magnetic flux densities of regenerative-track width of face, permanent magnet thickness, and a permanent magnet. Furthermore, the physical-properties value of the permanent magnet film has effect strong against the reinforcement of a bias magnetic field, distribution, etc.
[0016] therefore, although it is very difficult to combine the parameter of these large number appropriately, and to regulate it in practice, it can perform easily by this invention and it becomes possible to obtain the MR head which resembled output characteristics and noise figure markedly and was excellent in them compared with the conventional MR head.
[0017] In this invention, it is a main technique to stabilize MR component which is a sensing element which has a magneto-resistive effect by the bias magnetic field. In the magneto-resistive effect mold magnetic head equipped with the permanent magnet film for impressing a magnetic bias magnetic field to MR component which has a magneto-resistive effect, and this MR component, as for the MR head by this invention, the regenerative-track width of face when setting the residual magnetization Mr of w [mum] and the permanent magnet film and the product of Thickness t to Mrt [memu/cm2] and the relation of the residual magnetization thickness product Mrt of the permanent magnet film regenerative-track width of face Mrt>=1.0xw+0.5 (1)
Mrt<=3.6xw-0.4 (2)

While having the relation to satisfy, it is contingent [ on the regenerative-track width of face w being 1.5 micrometers or less ].

[0018] By using this MR head, even if regenerative-track width of face becomes narrow according to high track density, it becomes possible to acquire good reproducing characteristics with little dispersion in the asymmetry of a playback wave, a playback output, and a playback output. Furthermore, since the relation between the permanent magnet film from which a Barkhausen noise is effectively removable, and regenerative-track width of face can be used, the high engine performance is obtained.

[0019]

[Embodiment of the Invention] The structure of the magnetic pole section of the MR head by this invention is explained with reference to drawing 8 . In drawing 8 , a sign 82 is MR component, is made to adjoin the MR component 82 and forms the permanent magnet film 81. Moreover, the electrode for energizing a sign 83 for MR component and 84 are record magnetic poles. The MR component 82 is magnetically shielded with the lower shielding film 85 and the up shielding film 86.

[0020] The 1st example is explained. Let it be a technical problem to find out the conditions for realizing a non-object with the reproducing characteristics of an MR head near 0 in this example.

[0021] The relation of the unsymmetrical property of a playback wave over the residual magnetization Mr of the permanent magnet film 81 and the product (henceforth the product of the residual magnetization and thickness of the permanent magnet film) Mrt with Thickness t is shown in drawing 1 about each **** whose regenerative-track width of face w is 0.7-1.5 micrometers. The axis of abscissa of the graph of drawing 1 displays playback wave asymmetry as the residual magnetization and the thickness product Mrt of the permanent magnet film [memu/cm2], and an axis of ordinate displays it by %. Here, the asymmetry of a playback wave is defined by the following formulas.

In the formula on asymmetric [%] =[(V+-V-)/(V++V-)] x100, V+ and V- express a forward signal output and a negative signal output, respectively.

[0022] When reproducing the signal which was recorded like a hard disk drive unit and by which digital coding was carried out, the playback wave acquired from the magnetic head is an analog signal, and it is necessary to reproduce it to 0 or 1 digital sign after this. When said asymmetry increases, a playback wave is distorted and it becomes impossible to reproduce 0 or 1 sign correctly in this process.

[0023] Generally, asymmetric tolerance is made into -15 - +15% about the MR head included in a hard disk drive unit. However, since the error rate of a playback sign may become large about 10 to 100 times in this asymmetric tolerance, as for asymmetry, it is desirable that it is -10 - +10% of range.

[0024] So, in this invention, we decided to set up so that asymmetry whose reproducing characteristics of an MR head are -10 - +10% may be realized. An asymmetric value changes from forward to negative as Mrt of the permanent magnet film will be made to increase and it will go to regenerative-track width of face w of 0.7-1.5 micrometers so that clearly if the characteristic curve group shown in drawing 1 is seen.

[0025] For example, in the case of 0.7-micrometer regenerative-track width of

face, at the time of product Mrt=0.8[memu/cm2] of the residual magnetization and thickness of the permanent magnet film, if that whose asymmetry was +33% becomes Mrt=1.20[memu/cm2], asymmetry will be improved to +10%. Furthermore, if it becomes more than Mrt=2.24 [memu/cm2], asymmetry will become -10% or more. When the above result to the regenerative-track width of face w is 0.7 micrometers, the lower limit of the product Mrt of the residual magnetization and thickness of the permanent magnet film is 1.20 [memu/cm2], and a upper limit is 2.24 [memu/cm2].

[0026] If the above-mentioned procedure is applied besides regenerative-track width-of-face w=0.7 and the upper limit and lower limit of Product Mrt of the permanent magnet film in each width of recording track are calculated, it will become as in the following table 1. [ of residual magnetization and thickness ]

[0027]

[Table 1]

| | 永久磁石膜の残留磁化・膜厚の積Ｍｒ ｔ[memu/cm²] | |
|---|---|---|
| 再生トラック幅 [μm] | 下限 | 上限 |
| ０．７ | １．２０ | ２．４４ |
| ０．８ | １．３０ | ２．５０ |
| ０．９ | １．３８ | ２．７７ |
| １．０ | １．４３ | ３．１０ |
| １．１ | １．５５ | ３．４０ |
| １．２ | １．６８ | ３．６５ |
| １．３ | １．７８ | ３．９９ |
| １．４ | １．８８ | ４．５３ |
| １．５ | １．９９ | ５．２９ |

[0028] When relation with the regenerative-track width of face w is expressed with a straight-line type, respectively about the minimum and upper limit of Product Mrt of the permanent magnet film which were acquired in Table 1, about the lower limit of Mrt, it is Mrt=1.0xw+0.5. .... It is set to (1) and is Mrt=3.6xw-0.4 about the upper limit of Mrt. .... It is set to (2). [ of residual magnetization and thickness ]

[0029] In order to control the asymmetry of a regenerative signal in **10% of range from this result in the MR head which applied permanent magnet bias, it is required to choose the product Mrt of the residual magnetization and thickness of the permanent magnet film and the regenerative-track width of face w so that the range specified by the formula (1) and the formula (2) may be satisfied.

[0030] In addition, the regenerative-track width of face w since the property is so good that reproductive wave asymmetry is close to 0, and the relation of Mrt of the permanent magnet film are Mrt=1.6xw+0.4 from the result shown in drawing 1 . .... (3)

It turns out that it is most desirable to satisfy ******.

[0031] In order for the reproducing characteristics of an MR head to demonstrate the asymmetry near 0 from the above thing, it turns out that it considers as the range which made the above-mentioned (1) formula the minimum for the relation of the product Mrt of the residual magnetization and thickness of the permanent magnet film to the regenerative-track width of face w, and made the above-

mentioned (2) formula the upper limit, or that it is desirable to bring close to the above-mentioned (3) formula as much as possible.
[0032] Furthermore, the regenerative-track width of face w specified by this invention makes 1.5 micrometers an upper limit. That is, the upper limit of the regenerative-track width of face w is w= 1.5. .... (4)
It carries out. w= 1.5 [mum] is also the regenerative-track width of face corresponding to about two 2 GB/in surface recording density.
[0033] As mentioned above, if expressed with a graph by carrying out desirable relation of the product Mrt of the residual magnetization and thickness of the permanent magnet film to the regenerative-track width of face w specified by (1), (2), and (4) types, it will become the field which gave the slash surrounded in the straight lines 22, 21, and 23 of drawing 2 . An axis of abscissa is regenerative-track width-of-face w [mum], and the axis of ordinate of drawing 2 is the product Mrt of the residual magnetization and thickness of the permanent magnet film [memu/cm2]. In this drawing 2 , a straight line 21 is (1) type which has specified the minimum of Mrt, straight lines 22 are (2) types which have specified the upper limit of Mrt, and straight lines 23 are (4) types which have specified the upper limit of the regenerative-track width of face w.
[0034] That is, the field of this slash has satisfied the following three formulas.
Mrt>=1.0xw+0.5 .... (1')
Mrt<=3.6xw-0.4 .... (2')
w<=1.5 .... (4')
[0035] In addition, a formula (1) or the left part of (2) shows the residual magnetization thickness product Mrt of the permanent magnet film, and the dimension is [memu/cm2]. In addition, the regenerative-track width of face w will be displayed by mum. Since it has the dimension which left part mentioned above, the constant multiplier of the 1st term of the right-hand side will have [ [memu/cm2/micrometer] and the constant multiplier of the 2nd term ] the dimension of [memu/cm2].
[0036] The 2nd example by this invention is explained. In this example, the conditions that an MR head can secure a regular output are further added to conditions (conditions in the 1st example) for the reproducing characteristics of an MR head to realize less than **10% of asymmetry.
[0037] With hard disk drive equipment, in order to carry out record playback of the 0 or 1 sign, the magnetic reversal phenomenon recorded on a magnetic-recording medium is used. Although the magnetic field change accompanying the magnetic reversal in a magnetic-recording medium is changed into 0 or 1 sign from the playback wave by the MR head, as shown in {0000}, when zero code signal continues, for example in a sign array, a magnetic reversal period is long, and on the contrary as shown in {1111}, when 1 continues, a magnetic reversal period becomes short.
[0038] In the sign playback system used for current and a hard disk drive unit, although the ratio of lowest frequency and the highest frequency is set as the range of 1:5 thru/or 1:6, it has the inclination for a playback output to decrease, according to the cross protection of a playback wave by overlap with an adjacent signal wave, so that it becomes a RF. At this time, the amplitude intensity ratio of

a playback output to the playback output and lowest frequency to the highest frequency becomes about 25 – 35%.

[0039] Since about 1mV of playback outputs from an MR head is the need on the other hand in order to mistake by the hard disk drive unit and to carry out sign playback that there is nothing, as for the playback output in a low frequency region, it is desirable for there to be at least 0.3–0.4mV. For this reason, in this invention, it decided to find out the product Mrt of the residual magnetization and thickness of the permanent magnet film which can secure 0.4mV or more of playback outputs of a low frequency region.

[0040] The relation of the playback output of the isolated playback wave to the product Mrt of the residual magnetization and thickness of the permanent magnet film is shown in drawing 3 about each **** whose regenerative–track width of face w is 0.7–1.5 micrometers. The axis of abscissa of the graph of drawing 3 is the product Mrt of the residual magnetization and thickness of the permanent magnet film [memu/cm2], and an axis of ordinate is a playback output [mV].

[0041] According to drawing 3 , when the regenerative–track width of face w is 0.7 micrometers and the product Mrt of permanent magnet film residual magnetization and thickness is 0.88 [memu/cm2], it turns out that the playback output of about 0.5 [mV] is given, for example. Furthermore, by 0.7–1.5 micrometers, the regenerative–track width of face w follows on increasing, and, generally the product Mrt of the residual magnetization and thickness of the permanent magnet film shows the inclination for a playback output to decrease.

[0042] Moreover, in order to obtain the playback output more than 0.4 [mV] from drawing 3 in the case of w= 0.7–micrometer regenerative–track width of face, it turns out that it is required for the product Mrt of the residual magnetization and thickness of the permanent magnet film to be below 1.27 [memu/cm2]. Similarly, also about the case where the regenerative–track width of face w is except 0.7 micrometers, if the upper limit of the product Mrt of the residual magnetization and thickness of the permanent magnet film for obtaining the playback output more than 0.4 [mV] is calculated, it will become as it is shown in the following table 2.

[0043]

[Table 2]

| 再生トラック幅 [μm] | 永久磁石膜の残留磁化・膜厚の積Mｒｔの上限値[memu/cm²] |
|---|---|
| ０．７ | １．２７ |
| ０．８ | １．６８ |
| ０．９ | ２．０８ |
| １．０ | ２．５０ |
| １．１ | ２．９３ |
| １．２ | ３．３５ |
| １．３ | ３．８５ |
| １．４ | ４．３６ |
| １．５ | ４．９３ |

[0044] It is Mrt=4.5xw–2.0 when the relation of the regenerative–track width of face w is expressed with a straight–line type for the product Mrt of the residual magnetization and thickness of the permanent magnet film obtained in Table 2. ....

It is set to (5).
That is, it is Mrt<=4.5xw-2.0 in order to secure a playback output more than 0.4 [mV]. .... (5')
It comes out and a certain thing is needed.
[0045] In order to regulate the asymmetry of a regenerative signal to **10% of within the limits and for a playback output to secure from the above thing in the MR head using the bias magnetic field by the permanent magnet film more than 0.4 [mV], all of a formula (1'), a formula (2'), an above-mentioned formula (4'), and (5') an above-mentioned formula must be satisfied. A slash shows such a field to drawing 4 .
[0046] As for drawing 4 , regenerative-track width-of-face w [mum] and the axis of ordinate of an axis of abscissa are the products Mrt of the residual magnetization and thickness of the permanent magnet film [memu/cm2]. In drawing 4 , straight lines 21, 22, and 23 express (1) type, (2) types, and (4) types like the case of drawing 2 , and the straight line 33 expresses upper (5) types.
[0047] as mentioned above, as explained, in the MR head using the bias magnetic field obtained and depended on the permanent magnet film, it becomes possible to regulate the asymmetry of a regenerative signal to **10% of within the limits, and to secure a playback output more than 0.4 [mV] by choosing the field described with the slash of drawing 4 .
[0048] The 3rd example is explained. In this example, the conditions of reducing the hysteresis characteristic of the permanent magnet film are further added to the conditions (conditions given in the 1st example) that the reproducing characteristics of an MR head realize less than **10% of asymmetry. A hysteresis here means the hysteresis which appears in the output change characteristic curve of MR component, when the external magnetic field which changes continuously is added to an MR head. This hysteresis is given by change of an impression magnetic field, and change of an output. The dimension of a hysteresis is made into [mV-Oe] in this invention.
[0049] Drawing 5 is a graph with which the regenerative-track width of face w shows the relation of a hysteresis [ as opposed to / **** / of 0.7-1.5 [mum] / each / the product Mrt of the residual magnetization and thickness of the permanent magnet film ]. The axis of ordinate of the graph of drawing 5 is a hysteresis [mV-Oe], and an axis of abscissa is the product Mrt of the residual magnetization and thickness of the permanent magnet film [memu/cm2].
[0050] If drawing 5 is caused, when the regenerative-track width of face w is 0.7 [mum] and the product Mrt of the residual magnetization and thickness of the permanent magnet film will be 0.88 [memu/cm2], for example, a hysteresis is 4.2 [mV-Oe]. If Mrt increases from it and is set to 1.6 [memu/cm2], a hysteresis will decrease rapidly and will be set to 1.2 [mV-Oe]. If Mrt furthermore increases and it is set to 3.9 [memu/cm2], a hysteresis will decrease further and will be set to 0.2 [mV-Oe].
[0051] It turns out that the hysteresis which appears in a playback component generally causes dispersion in a playback output, and it becomes the noise source of disk drive equipment. For this reason, the greatest output dispersion permitted with disk drive equipment is about 5 - 10%, and if this is considered in the case of

the minimum value 0.4 of the aforementioned playback output [mV], the range of a permissible variation will be set to 0.03 [mV].

[0052] On the other hand, if it takes into consideration that Mrt(s) of a magnetic-recording medium are 0.5-0.8 [memu/cm2] speaking of the size of the signal magnetic field generated from the magnetic-recording medium of disk drive equipment, the magnetic field of 40 [Oe] extent will be considered to join the magneto-resistive effect mold magnetic head.

[0053] As for the maximum of the hysteresis permitted from this result, it turns out that it is specified from the magnitude of an impression magnetic field, and the product of an output permissible variation, and is set to 1.2 [mV-Oe]. In order to obtain a magneto-resistive effect mold head with little dispersion in a playback output, it is necessary to control Mrt of the permanent magnet film so that a hysteresis becomes below 1.2 [mV-Oe].

[0054] Based on the result obtained by drawing 5 , when the regenerative-track width of face w calculates the lower limit of the product Mrt of the residual magnetization and thickness of the permanent magnet film, it comes to show each **** of 0.7-1.5 [mum] in the following table 3.

[0055]

[Table 3]

| 再生トラック幅 [μm] | 永久磁石膜の残留磁化・膜厚の積Ｍｒｔの下限値 [memu/cm²] |
|---|---|
| ０．７ | １．６２ |
| ０．８ | １．８８ |
| ０．９ | ２．１４ |
| １．０ | ２．４２ |
| １．１ | ２．７２ |
| １．２ | ３．０７ |
| １．３ | ３．５０ |
| １．４ | ４．０４ |
| １．５ | ４．７３ |

[0056] It is Mrt=3.7xw-1.2 when the product Mrt of the residual magnetization and thickness of the permanent magnet film and the relation of the regenerative-track width of face w which were obtained in Table 3 are expressed with a straight-line type. .... It is set to (6).

That is, it is Mrt>=3.7xw-1.2 in order for the magnitude of the hysteresis which specifies dispersion in a playback output to carry out to below 1.2 [mV-Oe]. .... (6')

It comes out and a certain thing is needed.

[0057] In order to acquire the reproducing characteristics which controlled the asymmetry of a regenerative signal to **10% of within the limits, and made magnitude of a hysteresis below 1.2 [mV-Oe] in the MR head of a permanent magnet bias method from the above thing, all of a formula (1'), a formula (2'), an above-mentioned formula (4'), and (6') an above-mentioned formula must be satisfied. A slash shows such a field to drawing 6 .

[0058] The axis of abscissa of drawing 6 is regenerative-track width-of-face w [mum], and an axis of ordinate is the product Mrt of the residual magnetization and thickness of the permanent magnet film [memu/cm2]. In drawing 6 , straight lines

21, 22, and 23 express (1) type, (2) types, and (4) types like the case of drawing 2 , and the straight line 53 expresses upper (6) types.

[0059] The 4th example is explained. In this example, conditions (conditions in the 1st example) for the reproducing characteristics of an MR head to realize less than **10% of asymmetry and the conditions (conditions in the 3rd example) of reducing the hysteresis characteristic of the permanent magnet film further are overlapped, and are added.

[0060] Therefore, this example must satisfy all of a formula (1'), a formula (2'), a formula (4'), an above-mentioned formula (5'), and (6') an above-mentioned formula. A slash shows such a field to drawing 7 .

[0061] An axis of abscissa is regenerative-track width-of-face w [mum], and the axis of ordinate of drawing 7 is the product Mrt of the residual magnetization and thickness of the permanent magnet film [memu/cm2]. In drawing 7 , straight lines 21, 22, and 23 express (1) type, (2) types, and (4) types like the case of drawing 2 , a straight line 33 expresses upper (5) types, and the straight line 53 expresses (6) types.

[0062] The 5th example is explained. This example has specified that remanence ratio S in the MR head by the above-mentioned 1st thru/or the 4th above-mentioned example. A remanence ratio S is a ratio of the residual magnetization Mr of the permanent magnet film, and saturation magnetization Ms which is a means for impressing magnetic bias (namely, S=Mr/Ms). As for the MR head by this example, a remanence ratio is specified or less [ 0.7 or more ] to 1.0.

[0063] The saturation magnetization Ms of the permanent magnet film 81 in the MR head shown in drawing 8 becomes 450-800 [emu/cm3] extent. When a remanence ratio S is set to 1 at this time, thickness required since the product Mrt of the residual magnetization and thickness of the permanent magnet film is set to 1 [memu/cm2] is 120-220 [**]. On the other hand, if a remanence ratio S is set to 0.1, thickness required since Mrt is set to 1 [memu/cm2] will amount to 1200-2200 [**], and the regenerative-track both sides of a playback component will become thick.

[0064] The configuration of this playback component circumference will also affect the configuration of a record magnetic pole. In order to ease the size effect of the playback component circumference, before forming a record magnetic pole, it is required to perform flattening of the field which arranges a magnetic pole, or to keep a playback component configuration flat. However, the activity of flattening makes the manufacture man day of the magnetic head increase, and has the demerit in which it leads to the increment in cost. On the other hand, it becomes the technique which keeps the configuration of a playback component flat can also shorten the time amount of film formation by making the permanent magnet film thin, without passing through an excessive process, and possible to raise the productivity of an MR head.

[0065] The maximum of the product Mrt of the residual magnetization and thickness of the permanent magnet film 81 used by this example is 5.29 [memu/cm2]. When saturation magnetization Ms uses the permanent magnet ingredient of 450 [emu/cm3] for the permanent magnet film 81, the thickness is given by the following relation.

Permanent magnet thickness =(maximum of product Mrt of residual magnetization and thickness)/(residual magnetization Mr)
= Mrt/(MsxS)
=5.29[memu/cm2]/Mr[emu/cm3]
= 5.29 [memu/cm2] /(450 [emu/cm3] xS)
It becomes.
[0066] Therefore, the minimum thickness of the permanent magnet film is obtained when a remanence ratio S is 1, and it is set to 1176 [**]. A remanence ratio S follows on becoming small, the thickness of the permanent magnet film becomes thick, and it amounts to 1680 [**] in a remanence ratio 0.7, and it amounts to 2352 [**] in a remanence ratio 0.5. The component thickness of an MR head is 500-600 [**] extent, and the level difference of the component section which added the electrode for signal detection to this becomes 2000 [**] extent at the time of a remanence ratio 0.7. Although this makes a record magnetic pole generate distortion which reaches 50% of record gap length, in order that the configuration distortion of 50% or more may degrade remarkably the property of O/W (exaggerated light) and playback wavelength, as for the remanence ratio of the permanent magnet film, it is desirable that it is 0.7 or more.
[0067] This example has specified the presentation of that permanent magnet film 81 in the MR head by either among the above-mentioned 1st thru/or the 5th above-mentioned example. The permanent magnet film 81 is an alloy which uses Co as a principal component, and even if there are little Cr, Ta, Pt, and nickel as an alloying element to this alloy, it includes any one or more kinds.
[0068] In an MR head, in order to control the product Mrt of the residual magnetization and thickness of the permanent magnet film which generates a bias magnetic field and to acquire good reproducing characteristics, it is necessary to obtain the permanent magnet ingredient in which magnetic properties excellent in the condition of a thin film are shown. Thickness is able to secure S= 0.7 or more remanence ratios more than coercive force Hc=1000 [Oe] in 100-1000 [**] by the permanent magnet film of the alloy which uses Co as a principal component.
[0069] The 7th example is explained. The playback component which has a magneto-resistive effect in the MR head by either consists of this example among the above-mentioned 1st thru/or the 6th above-mentioned example with two magnetic films by which the laminating was carried out through the spacer of non-magnetic metal. It is possible to use ingredients, such as Cu and Ta, as a spacer of this non-magnetic metal. Moreover, as a magnetic film by which the laminating was carried out, it is possible to use NiFe, Co, NiFeCo, CoFe, CoTaZr, a NiFe system alloy, a CoFe system alloy, a CoTa system alloy, etc., and good magnetic properties can be acquired.
[0070] The 8th example is explained. In this example, a playback component can be made into the following gestalten in the MR head by either among the above-mentioned 1st thru/or the 6th above-mentioned example.
[0071] The 1st gestalt: It considers as three layer membranes which carried out the laminating of the magneto-resistive effect film (MR film), the spacer of Ta, and the SAL film that impresses bias to MR film, and the permanent magnet film and the electric conduction film are prepared in the both ends of these three layer

membranes, and it considers as a playback component. The spacer of the high metal membrane of resistance is obtained by setting a spacer to Ta. The MR head using this playback component is called the SAL bias mold magnetic head.
[0072] The 2nd gestalt: It considers as four layer membranes which carried out the laminating of the 1st soft magnetism film, the spacer of non-magnetic metal, the 2nd magnetic film, and the antiferromagnetism film, and the permanent magnet film and the electric conduction film are prepared in the both ends of these four layer membranes, and it considers as a playback component. Spin bulb mold MR head **** is called a spin valve head for the MR head using this playback component. In addition, in this playback component, things can be permuted and carried out in both the 1st soft magnetism film and 2nd magnetic film and the film which crawled and carried out the laminating of two or more magnetic films for a gap or one side, the laminating ferry layer which prepared the metal layer between magnetic layers. Cu etc. can be used for the spacer of non-magnetic metal.
[0073] Here, a spin bulb mold MR head is explained using drawing 9 , drawing 10 , and drawing 11 . The playback component which consists of the MR component 82 of the four above-mentioned layer membranes, permanent magnet film 81 prepared in the both ends, and an electrode 83 (electric conduction film) is arranged between the 1st shielding magnetic film 93 and the 2nd shielding magnetic film 94. The 2nd shielding magnetic film 94 is placed through an insulator layer 96 on a substrate 95. The 1st shielding magnetic film 93 maintains a predetermined gap above the 2nd shielding magnetic film 94, and is arranged.
[0074] The record magnetic pole 84 is arranged above the 1st shielding magnetic film 93. The record magnetic pole 84 is back prolonged even at the core of a coil 80, as shown in drawing 9 . This record magnetic pole 84 is covered by the protective coat 97, as shown in drawing 10 . The MR components 82 which constitute a playback component are mainly 4 layer structures of 82d of antiferromagnetism layers which consist of the bottom to free layer 82a as 1st soft magnetism film, non-magnetic metal layer 82b as a spacer, fixed-bed 82c as the 2nd magnetic layer, and the antiferromagnetism film, as shown in drawing 11 .
[0075] The 3rd gestalt: The electric conduction film is prepared in three layer membranes which carried out the laminating of the 1st soft magnetism film, the spacer of an insulating material, and the 2nd soft magnetism film, and these three layer membranes, and it considers as a playback component. The MR head using this playback component is called the tunnel junction mold magnetic head.
The 4th gestalt: The playback component which produces giant magneto-resistance is used.
[0076]
[Embodiment of the Invention] The MR head of this invention was manufactured at the following processes, and it decided to prove the effectiveness of this invention. First, the lower shielding film which consists of soft magnetic materials of the thickness of 1-2 [mum] on the ceramic substrate in which the insulator layer of aluminum2O3 grade was formed was formed. After operating the lower shielding film orthopedically in a form required for the magnetic head, the lower playback gap using the insulator layer of aluminum2O3 grade was formed. On this insulator layer, approaches, such as a spatter, were used in order of the soft magnetism film, the

nonmagnetic spacer film, and a magnetic film, and the laminating thin film for playback components was formed. At this time, these film needs to be thin films of 100-200 [**] extent. The formed laminating thin film is orthopedically operated by the required component configuration by technique, such as milling (it is also called ion milling).

[0077] Next, the electrode for detecting resistance change of a playback component is produced. Since it became spacing of two electrodes in contact with a playback component, specifying the regenerative-track width of face w formed the stencil for controlling an electrode spacing first on the playback component using the technique of photolithography. the component width of face in which the part in contact with the playback component of a stencil was formed of milling since the electrode material to form needed to connect with the playback component good electrically at this time so that it might mention later -- 0.2-0.3 [mum] extent -- it needed to narrow. At this time, regenerative-track width of face regulated by the width of face of a stencil was set to 0.7-1.5 [mum]. Among the film which constitutes an electrode, first, Ta film and Cu film which are an electric good conductor were continuously formed [ adjusted thickness and ] membranes and formed to the 1st so that the product Mrt of required residual magnetization and thickness might be obtained for a CoCrPt alloy as permanent magnet film for bias magnetic field generating.

[0078] At this time, the product Mrt of the residual magnetization and thickness of the permanent magnet film formed membranes on condition that 0.8-3.9 [memu/cm2]. The permanent magnet film and the electric conduction film were formed using the spatter. After the membrane formation activity by the spatter was completed, the film which adhered on the stencil and the stencil was removed, and the insulator layer which consists of aluminum2O3 grade again was formed on the completed playback component. This insulator layer constitutes a playback gap together with the insulator layer of the playback component lower part. Furthermore, on the playback gap, the up shielding film of thickness 3-4 [mum] was formed. The laminating of a record coil and the record magnetic pole was carried out to the upper part of the completed reproducing head, the protective coat and the electric conduction pad were attached in the upper part, and the head production process of a way was completed.

[0079] The playback wave asymmetry of the prototype MR head which set Mrt of 0.7-1.5 [mum], and the permanent magnet film to 0.8-3.9 [memu/cm2] for the regenerative-track width of face w, a playback output, and the measurement result of a hysteresis are as having been shown in drawing 1 , drawing 3 , and drawing 5 , respectively.

[0080]

[Effect of the Invention] By using the MR head by this invention, even if regenerative-track width of face becomes narrow according to high track density, it becomes possible to acquire good reproducing characteristics with little dispersion in the asymmetry of a playback wave, a playback output, and a playback output. Furthermore, since the relation between the magnet film from which a Barkhausen noise is effectively removable, and regenerative-track width of face can be used, a highly efficient MR head is obtained.

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[Translation done.]